Scientific Animations Without Borders℠: An International Collaborative Approach for Building Scientific Educational Materials for Use on Cell Phones and the Internet in Developing Nations

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Abstract: International organizations, government agencies, non-governmental agencies, researchers, adult educators, and extension agents have long sought effective ways to provide useful information to the least educated people throughout the world. Although there is no absolute relationship between poverty and illiteracy, many poor people are also low-literate learners (or illiterate) and many live in rural areas of developing countries. Most educational materials targeting low-literate or illiterate individuals have involved the use of books, radio programs, or television. However, an estimated 80% of people living in rural areas of developing countries now have access to information via cell phones. The rapid development of cell phones and the Internet has also changed how people learn in that both literate and illiterate learners are increasingly familiar with and receptive to technology-mediated activities. Regardless of their level of formal education, many people interact with technology, discover things for themselves, and learn through multi-media. Therefore, providing useful information to illiterate individuals should no longer depend only on books, radio, or television programs; educators should now recognize that the cell phone is a valuable learning tool. Here we describe how information in the form of short animations can be transferred to those who deliver information to low-literate learners and to the learners themselves via cell phones. Voice overlays in a diversity of languages can be added to these animations so that ideas can be efficiently shared across language groups. The animated videos, which are being developed by Scientific Animations Without Borders℠ (SAWBO℠), can be viewed on cell phones or other video capable electronic devices. The development of these animations is multi-disciplinary and horizontal in that it involves the free exchange of ideas amongst collaborators through the utilization of social networks and cell phone technology.

Keywords: Adult Literacy Level, Indigenous Knowledge, Cell Phones, Bluetooth® Technology, Animated Videos, Developing Countries

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COMMON GROUND

Introduction

NATIONS AROUND THE world have agreed that literacy benefits individuals, communities, and countries, but current reports reveal that a great number of people remain illiterate (UNESCO, 2002, 2006a). Literacy has been associated with development and progress, and illiteracy with poverty and underdevelopment. Indeed, the most developed nations report the highest rates of literacy while the least developed countries, where the poorest and most marginalized have yet to be reached, report the highest rates of illiteracy (UNESCO, 2002). Over the last 50 years, the number of illiterate adults around the world has decreased slightly, from 847 million in 1970 to 824 million in 2010, and the number is estimated to be 799 million in 2015 (UNESCO, 2002). The highest illiteracy rates are found in Africa, South and West Asia, and the Arab States. Over 75% of all illiterate people live in 12 countries, with the majority of these people living in China and India (UNESCO, 2006a). One of the major barriers to learning for illiterate or low-literate individuals, and especially for those living in remote areas, is their inability to access information that could benefit their daily lives. For example, they have difficulty accessing information concerning improvements in agricultural practices or health care. Accessing information could also be crucial for reducing injury and other problems generated by natural and man-made disasters.

While most nations have attempted to reduce illiteracy by the traditional method of classroom teaching, recent developments in information and communication technologies (ICT) have brought new opportunities to reduce illiteracy in developing nations. ICT has been broadly defined as "forms of technology that are used to transmit, store, create, share, or exchange information" (UNESCO, 2006b). This broad definition not only includes computers, satellites, and high-speed Internet, but also radio, television, video, DVD, telephones (land lines, cell phones, etc.), teleconferencing and videoconferencing. These technologies represent significant teaching resources, in part, because they accommodate multiple learning styles and forms of intelligence - abstract, textual, visual, musical, social, and kinesthetic (Brown, 2000). Because these technologies can effectively combine written words, spoken words, and static and moving images, they can ultimately facilitate reading comprehension and learning (UNESCO, 2006b).

Technologies, such as the Internet and cell phones, can also benefit low-literate learners living in developing nations, but only if the technologies transmit content that is useful for those individuals with the aforementioned literacy levels. Traditionally, the creation of content for illiterate or low-literate people has focused on reading and writing. This content, however, is often inaccessible to the target audience and therefore ineffective. In this paper, we describe a recently developed project to create and deploy animated videos that can be uploaded onto cell phones and transmitted from cell phone to cell phone through Bluetooth® technology. The content of such animated videos is educational and has the immediate goal of bettering the lives of people, especially those living in remote and undeveloped areas. The content can be highly diverse and can include topics such as how to increase crop production, how to improve nutrition and health, as well as how to respond to storms, drought, earthquakes, and other natural and man-made disasters. The program is called Scientific Animations Without Borders℠ (SAWBO℠) and involves an international network of individuals and organizations that create these materials through a virtual network of collaborators. The current animations are based on concepts that are presently being used in extension

programs in West Africa, with new animations in progress for delivery to Haiti to help with disaster-related problems.

Definition of Illiteracy

Literacy and illiteracy are not easily defined concepts. In 1978, UNESCO proposed two definitions of illiterate persons that would help establish the International Standardization of Educational Statistics: 1) "an illiterate person is someone who cannot read and write, with understanding, a short simple statement about his or her everyday life." Given that literacy is more than just the acquisition of technical skills and that the concept of literacy should include the context and motivation of learners (UNESCO, 2006a, 2006b), a second definition was proposed: 2) "a person is functionally illiterate who cannot engage in all those activities in which literacy is required for effective functioning of his [or her] group and community and also for enabling him [or her] to continue to use reading, writing and calculation for his own and the community's development" (UNESCO, 1988, 2006a, 2006b). In the following article, we use the term low-literate learners to include individuals that are completely illiterate and those that are moderately literate. We recognize technology that is effective in conveying information to illiterate and low-literate learners should also be effective in conveying information to literate learners.

Facts about Cell Phone and Internet Access

According to the International Telecommunication Union (ITU, 2010), there is a great potential for using technology, especially cell phones, to impact illiterate adults living in rural areas in developing countries. The ITU (2010) estimated that there are currently around 5.3 billion mobile cell phone subscriptions worldwide. Access to mobile networks is available to 90% of the world and to 80% of the populations living in rural areas in developing nations. Access to the Internet, in contrast, is limited in developing countries. Thus, 71% of people in developed countries, but only 21% of those in developing countries, are online. Additionally, cell phone use and access is likely to continue to outpace increases in access to the Internet. For example, the developing world has increased its share of mobile subscriptions from 53% in 2005 to 73% in 2010 (ITU, 2010). Still, the potential value of Internet access for the developing world should not be ignored. For example, Internet access at home increased by 14% between 2009 and 2010 in developing countries (ITU, 2010). Thus, although there is great potential to deploy information through cell phone networks, the numbers of Internet users are also significant. It follows that the development of educational materials for low-literate learners should be both Internet and cell phone capable.

With the recent availability of cell phone technology and the decrease in the cost of acquiring and using them, especially in most parts of the developing world, extension programs and organizations now have a new and effective tool for interacting with low-literate and literate groups around the planet. The cell phone technology, of course, goes beyond the simple exchange of spoken words. Cell phones are also capable of transmitting files, videos, and other kinds of information. Video files that are commonly used on cell phones, fortunately, include both 3gp and AVI formats, both of which can be transmitted easily via the Internet and are computer compatible.

Challenges in the Deployment of Information for Low-Literate Learners and New Opportunities for Innovative Deployment Strategies

The recent development of new technologies such as the World Wide Web (WWW) and cell phones has dramatically improved the availability of "printed" educational information to those who are literate but not to those who are low-literate. Educators increasingly acknowledge that people learn differently today than in the past because of their high dependency on technology-mediated activities (DeGennaro, 2008). For literate learners, the WWW provides a diversity of options for obtaining scientific information that can benefit their lives. The ability to access and understand relevant scientific information can also greatly enhance the daily lives of low-literate learners (Souter et al., 2005). Access to such information can, for example, improve health, increase access to water, increase the productivity and well-being of livestock, improve the control of local crop pests, and improve participation in the marketplace (Bello-Bravo et al., 2010). Traditional extension programs, which help deploy such information, often have extremely limited resources in developing nations, and these programs therefore frequently fail to benefit their target audience. Moreover, access to written educational content will not benefit the target audience if that audience cannot read or otherwise understand the content.

Strategies for Development of Content for Low-Literate Learners

Cell phone use has dramatically risen in developing nations, and cell phones now represent an important new way by which educational content can be effectively and easily exchanged among peoples with different languages and cultures. What is needed now is a form of educational content that is compatible with this new technology, is useful for low-literate learners both in terms of presentation and content, and can be rapidly and efficiently developed. Given that low-literate learners are members of diverse cultures and speak a wide range of languages, the form of the information should be pictorial and spoken rather than written. Although a variety of approaches can be taken (e.g., the use of still pictures and PowerPoint® style presentations), two major options currently exist for development of materials for viewing on video-capable cell phones: live action films or animations.

Live Action Filming

Live action filming with local actors has an important advantage in that local people see others in their same local environment. Live action filming, however, has significant limitations. First, filming of live actors can be costly, in part because it requires a filming crew in each area where the videos are produced. Second, when one wants to make a video with a different language or for a different cultural group, one would need to overdub in a new language or re-film in the new area. Continued re-filming in different cultural and language groups is expensive. Third, live action filming does not generally lend itself to the development of a virtual network of collaborators (including volunteers) who can develop materials in different areas of the world for deployment into targeted regions. Animations, in contrast, can be developed through networks of individuals located in most regions around the world and do not have many of the other aforementioned limitations described for live action filming.

Animations and Voice Overlays

With the advent of the digital era and the advancements in psychological and communication studies, animation is now considered a "mature arts medium" (Wells, 2008). Animation provides an excellent opportunity for the development of new educational materials for low-literate learners across a diversity of cultural and language groups. The power of animation lies in its ability to communicate ideas while generating emotions in the audience. Animated films and videos can make use of both logic and emotion to effectively deliver the desired message (Pereira, 2005; Mayne, 1993). The creation of iconic animated characters can generate empathy between the viewer and the character and can thereby increase the willingness of the viewer to understand and accept the new information. Additionally, scripts containing appropriate content can be obtained from one part of world, animations can be created in other areas of the world, and voices can be overlaid in a diversity of languages from around the world (Figure 1). Finally, all the necessary materials can be transferred between co-creators through the WWW.

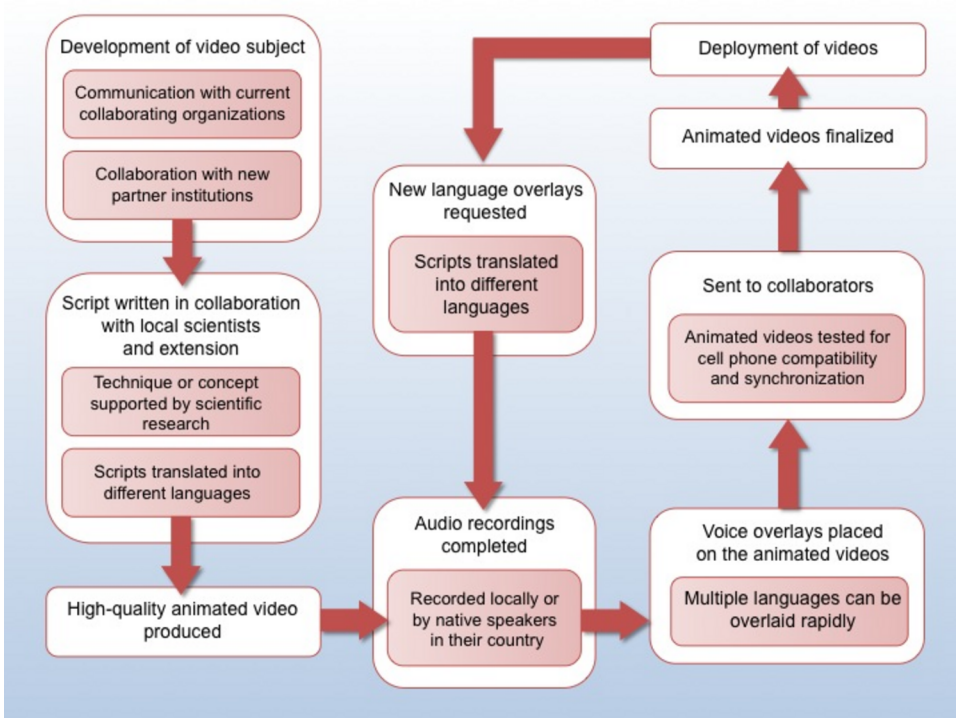

Figure 1: Flowchart explaining the development of animated videos and voice overlays through an international network of collaborators.

Sources of Information for the Development of Content

There are many different sources of useful information for people living in developing and developed countries, and these include large national and international public organizations, non-government organizations (NGOs), companies with access to the needs of local populations and with an interest in public service messages, social entrepreneurial efforts (company or organizations; e.g., shea butter production in West Africa), peer-reviewed and gray literature (non-peer reviewed), inventors, and indigenous knowledge. At least some of the previously mentioned organizations have a history of developing techniques and educational content that can benefit people in both developing and developed nations. These educational materials concern topics in healthcare, agricultural production, engineering, and other local problems. Hence, such existing materials become an important starting point for the development of animations.

The creation of such animations have and will certainly continue to depend on the availability of resources as well as the opportunities to work with groups that can provide starting materials, participate in the verification of the accuracy of the animations, and play an active role in the release of such animations. For example, *Institut d'Economie Rurale* (IER) in Mali has successfully used neem seed extracts to create a natural insecticide that can be sprayed on crops to control pest insects. The starting materials used by SAWBO℠ to create the "neem spray animation" were based on cartoon drawings utilized to show farmers how to create pesticide sprays from neem seeds (Figure 2). The "neem spray animation" was created based on a request by an IER scientist, who had observed that neem spray training modules were effective in educating and benefiting farmers. Thus, obtaining materials from those groups that directly deploy the educational materials in the field can ensure that the content is relevant to the target audience (Figure 2).

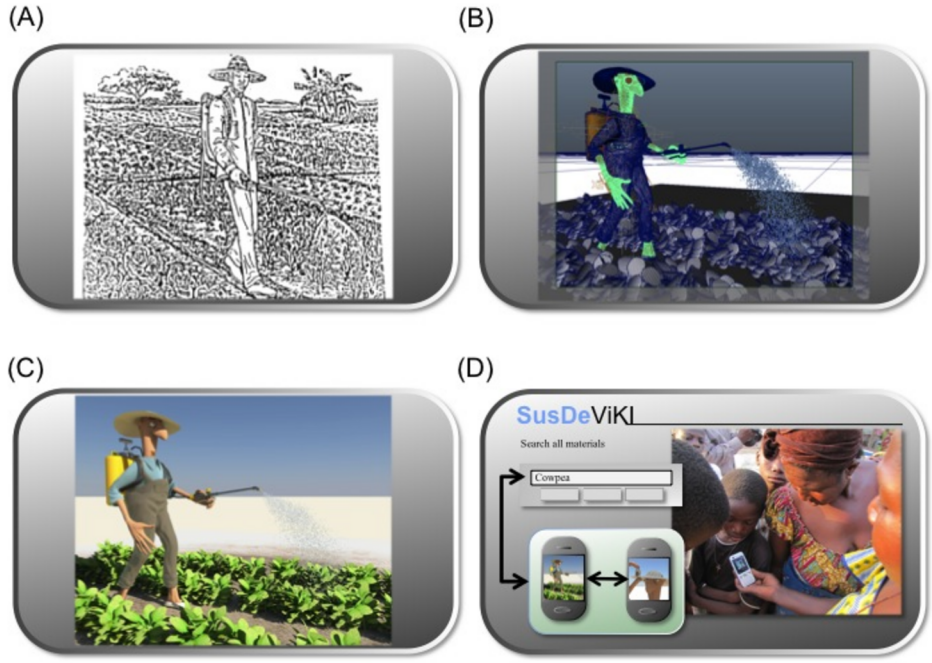

Figure 2: Steps taken in the creation and the deployment of an animated video: the production and use of neem sprays is used as an example. (A) Existing extension materials are used as the basis for the development of the animations [drawing courtesy of Institut d'Economie Rurale, Mali]. (B) A wire framework is initially developed, and once the initial concepts of the scenes are accepted. (C) A complete draft of the animated video is created and edited, and a final version is produced with voice overlays. (D) The final cell-phone-ready animated videos can be placed on the Sustainable Development Knowledge Interface (SusDeViKI; Bello-Bravo et al., 2010) for easy download onto a computer and transfer onto cell phones, where the animated videos can be transferred between cell phones, via Bluetooth® Technology, and used by farmers in the field. The picture of the individuals watching the cell phone is courtesy of Dr. Tamo of IITA in Benin.

Although early animations have focused on helping subsistence farmers control crop pests in developing countries, such animated videos may contain messages aimed at a larger portion of the population, especially those living in areas subject to earthquakes, tornadoes, hurricanes, wildfires, and other natural disasters. Simple messages can help people prepare for catastrophic and emergency situations. Animations can also help in the prevention and control of epidemic diseases. For example, the SAWBO℠ team has created an animated video for the prevention and control of cholera in Haiti and the Dominican Republic. A script was given to the animation team, and the animation was then created and reviewed. Upon approval, language overlays were created in Creole, French, Spanish, and English, and the animations were given out to a diversity of organizations for free distribution.

The cholera situation in Haiti represents an excellent example of how animations can be used in a crisis in a developing nation. Text messages and other forms of written information would be largely ineffective because about 40–50% of the Haitian population is illiterate (UNESCO, 2010). Since many of the illiterate people in Haiti speak Creole, we developed an animation narrated in Creole (in addition to those in other languages) with a local accent to facilitate the understanding of techniques for the prevention of cholera.

Although books, periodicals and other sources of information in the literate world are valuable sources of information, indigenous knowledge also represents an important resource for developing solutions to many challenges in developing nations (Mihale et al., 2009). Indigenous knowledge can be defined as information, perceptions, and behaviors that ultimately guide decisions concerning the use of land, the use of natural resources, and the enhancement of human well-being by local communities. Such knowledge is often created and sustained by the local community members as they try to meet their basic needs, including those of sustenance, housing, health-care, religious matters, and financial reserves (Daes, 1993). Although indigenous knowledge can be simple or complex, it is almost never static; it constantly evolves in response to new challenges associated with changes in ecological, economic, and sociopolitical circumstances. Indigenous knowledge is based on the creativity and innovation of community members but is also influenced by outside cultures and external technological changes. Indigenous knowledge has classically been passed from one generation to the next through example, ritual, stories, and other forms of oral transmission. For the purpose of this paper, we will use the terms "indigenous", "local", and "traditional" interchangeably.

Indigenous knowledge differs from scientifically-generated knowledge, and each has advantages and disadvantages. Unlike the indigenous knowledge generated by farmers, knowledge generated by scientists is typically based on experiments that include controls, replication, and statistical analysis (Lyotard, 1987), which is an advantage. A disadvantage is that the academics that generate scientific knowledge are often not the direct users of that knowledge and in many cases are not directly linked with those communities where the knowledge will be implemented. Thus, in focusing on long-term understanding, academic researchers may overlook local and/or practical aspects that can greatly affect how that knowledge may ultimately be used in the local community. In contrast, traditional knowledge is often created by the same people who depend on that knowledge for achieving a profit and, in many cases, for surviving (Berkes et al., 1992); it represents knowledge that may not have been verified according to scientific standards but is considered useful within the local communities. Traditional knowledge is closely related to the day-to-day and season-to-season requirements of the users. Instead of being separated, local knowledge and scientific knowledge should be integrated to achieve the greatest benefits to the local users.

As noted earlier, scientific knowledge is often presented in a technical language that is inaccessible to farmers and especially to low-literate farmers in developing countries. Indigenous knowledge can also be difficult to access or understand by the general world population and by the scientific community, especially for individuals who do not directly interact with those communities where the indigenous knowledge is generated. Although indigenous knowledge is readily shared among members of the local community where it is generated, it is not easily shared with communities in other regions and countries, thereby limiting the ability of the rest of the world to document, store, and access this knowledge. Also, because indigenous knowledge is embedded in the practices and experiences of a particular community

or group of people, it is most commonly exchanged through personal/oral communication and demonstration, which makes dissemination to other communities in other regions a significant challenge (World Bank, 1998).

Another problem with indigenous knowledge concerns its survival. Strong global trends tend to impose uniform processes that oppose diversity and heterogeneity. Many communities throughout the planet find it difficult or impossible to resist the homogeneity resulting from the accelerating rates of globalization (Jude, 2003), especially in light of increased Internet and cell phone access. As access to communication technology increases, most information and knowledge originates and radiates from central areas, flowing rapidly from centers to peripheral areas, but flowing slowly in the other direction. As a result of these trends, indigenous knowledge and indigenous identity are on the brink of extinction in many parts of the world (Mizrahi, 2007). The risk of losing indigenous knowledge is likely to increase as previously remote (and often rural) areas of the planet gain access to communication technologies.

The two problems concerning indigenous knowledge (that it is often available only where it was generated and that its existence is threatened) can be reduced by animations. First, the use of animations and voice overlays makes it possible to capture, store, and transmit indigenous knowledge among communities that are separated by language, mountains, oceans, or by other physical and cultural barriers. Second, animations have the potential to facilitate the rescue, restoration, and preservation of indigenous knowledge and therefore help secure the identity of those communities where the knowledge was generated.

Creation Process: Techniques Applied in the Production of Our Animated Videos

Screen Writing and Technical Development

The development of any animation that attempts to capture, document, and deploy either scientific or indigenous knowledge must take into account the psychological and socio-cultural factors inherent to the individuals and groups where the message will be disseminated. As humans, our different cultures and our different personal experiences influence how our minds develop mental images about the reality that surrounds us (Gould and White, 1986; Lynch, 1960). It is important to realize that problems (e.g., environmental hazards) and opportunities (e.g., local resources) are considered subjective realities and may be perceived differently by individuals based on multiple and complex factors like age, occupation, gender, and cultural background (Bechtel, 1997). Therefore, the behavioral responses to everyday life events or to catastrophic situations may differ greatly among different groups of humans (Garling and Gollege, 1993; Palm, 1990). Thus, we are using a co-creation methodology that is inherently interactive and favors "horizontal" relations with all of the participants for animation realization and deployment. During the script writing, specialists, creative artists, and collaborators freely exchange scientific information, local knowledge, new ideas, informal opinions, and different point of views. Feedback based on local perspectives and other interpretative factors are usually introduced to correct deficient narratives or to include missing information. Therefore, before the script is finalized and turned into an animated video, everyone involved in its creation must scrutinize the draft version (Figure 2). In the case of

indigenous knowledge, this review should likely include team members who are academics and those who are the direct practitioners of the indigenous knowledge.

The script contains a detailed chronological story describing the actions, displacements, and interactions to be performed by the characters and objects. This text is then transformed into digital images (Pereira, 2005). The script also contains the narratives that will complement and support the actions of the characters. For the development of animated videos, we have used two-dimensional (2D) animation techniques but we more commonly use three-dimensional (3D) animation techniques. Once the script is ready for technical production, a team of artists and computer science specialists will interpret the text and create the geometric entities as mathematical 3D models. These entities are transformed into objects and characters that perform the actions described in the script. By a process known as "3D rendering", the objects and characters are placed in a contextual position in the scenes where the actual "animation" is generated through the interaction between light, actions, and the concatenation of movements.

Once the first draft of the animated video is completed, we then have it reviewed by all team members and collaborators (Figure 2). Suggestions and modifications are once again considered and incorporated to ensure that the final version fulfills the needs and expectations of everyone involved. Although the methodology described requires time and dedication, it helps the animated video to convey both scientific and indigenous knowledge, and it ensures that the information is relevant and accessible to the local culture. At the same time, the methodology generates a flexible base that can be adapted for deployment in different areas and human contexts.

Release Strategies

Dissemination of Animations

The overall current SAWBO^{SM} deployment strategy involves releasing the animated videos in a file format suitable for viewing and transferring both through the Internet and on cell phones. Campaigns that use "traditional mass media", such as radio and television, need to take into consideration that the transmission of concepts are limited by these often costly forms of media. In order to achieve a degree of retention of basic concepts, traditional mass media expose the "audience" to a certain number of consecutive message repetitions in which the flow of information follows a one-way pattern (from medium to audience). In contrast, the flow of information through social networks and cell phones is, by nature, interactive and may follow one-way, two-way, or multidirectional flow patterns. Another important difference is that the information contained in messages, clips, and videos can be easily stored in the memory of cell phones or electronic devices. Users can access that information as many times as needed, and the information can be instantly forwarded to others. When viewing content on the Internet, users may post comments and in turn can forward it to others as well. The ability to share that information, add comments, suggestions, and recommendations and to share links helps the original message to gain value and to rapidly acquire a "socio-referenced" significance (Shibutani, 1955).

Three animated videos related to agricultural pest management have been effectively employed in educational campaigns in Africa and around the world. As SAWBO^{SM} continues to develop more animated videos, to expand video functionality to disaster/crisis situations,

and to improve the quality of the videos, the methodology of dissemination of the animated videos is changing as well. With any animated video campaign, the dissemination process could certainly include public and private sectors. Initially, the first animated videos were disseminated via three main technologies associated with the public sector: 1) e-mails; 2) a centralized website; and 3) cell phone to cell phone via BlueTooth® technology. The public sector e-mail communication was primarily with non-governmental organizations, public organizations (i.e., government agencies or universities), and other local extension groups worldwide. The development of additional animated videos, especially those related to crises in specific countries or regions, has prompted the SAWBO^{SM} team to turn to private companies, in addition to or in conjunction with public organizations, for help with dissemination. The private sector will ideally include companies and/or universities that have the resources and capabilities to efficiently distribute the animated videos to the target audience.

In selecting the most effective dissemination approach, some key factors must be considered. As noted earlier, one critical factor is the target audience. Dissemination will also depend on the nature of the content (e.g., agriculture versus health, or routine activities versus crisis events) and the networks available in the target countries and regions. In most scenarios, the best dissemination approach will involve a combination of individuals and organizations from both public and private sectors.

Impact Assessment of Animated Videos

With any type of extension program, the impact of developed materials on the target audience should be monitored. In a 2009 review article on current approaches to observing the effectiveness of agricultural development, Maredia (2009) defines impact assessment (IA) as "the systematic analysis of the significant or lasting changes—positive or negative, intended or not—in people's lives brought about by a given action or series of actions in relation to a counterfactual scenario." IA can be categorized into two main areas: (i) macro-level IA and (ii) micro-level IA. Macro-level IA involves the long-term impacts of the program while micro-level IA tends to provide feedback throughout the overall implementation of the program in regards to the short-term and medium-term goals.

The SAWBO^{SM} team is currently developing a procedure to monitor the macro-level, long-term impacts of the project. With regard to micro-level IA, SAWBO^{SM} is receiving feedback primarily from organizations involved in the creation process and those organizations involved in the direct use of the technology. The feedback received is helping to improve the quality of the animated videos and is suggesting new topics for future videos. As the team continues to develop more animated videos and to expand the project beyond the realm of agriculture, it will be important to continue to extend the IA.

Challenges Related to Monitoring the Impact Assessment

With respect to monitoring how the animations have impacted local farmers and communities across the world, feedback is limited by technical, bureaucratic, and political factors (Center for Global Development, 2006). Because most of the actual dissemination of the videos will be between local NGO's/organizations and farmers or between local farmers themselves, determining the exact number of individuals who have viewed the videos is difficult. While videos could be tagged to monitor when they are downloaded and transferred from cell phone

to cell phone, this involves ethical issues related to the use of human subjects and individual rights of privacy. The collection of human data requires informed consent and preservation of anonymity. Other questions are "How do we determine whether the information viewed by the individual farmer is actually being implemented?" and "Is the knowledge gained beneficial to the overall community?" As mentioned previously, the current strategy for assessing distribution and impact of the animations is to rely on collaborator and NGO/organizational feedback.

Conclusions

We recognize that the use of animated videos for scientific educational purposes for low-literate learners is still in its infancy. There is a tremendous need to develop networks of people and organizations that can facilitate the development of educational content for such animations. Also needed are people and organizations who can provide local language adaptations and who can efficiently deploy the completed animations. We believe that the animation development system described here will be useful across a diversity of communities of both low-literate and literate learners.

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